

# Urban Computing Framework for Smart and Sustainable Neighborhoods

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Urban computing is the incorporation of computing, sensors, and actuation technology into urban life. In Saudi Arabia, the neighborhoods lack an integrated approach to social, economic, and environmental values, thereby creating consequences, such as inefficient mobility, poor environmental protection, low quality of life, and inadequate services or facilities. Saudi Arabia was used as a case study to develop an urban computing framework for smart sustainable neighborhood.

Keywords: smart neighborhood ; sustainable indicators ; sustainable development goals (SDGs)

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## 1. Introduction

Cities are currently acting as engines for economic development, providing opportunities for expansion while dealing with several internal and external challenges, such as environmental hazards, resource depletion, high energy consumption, and high production of CO<sub>2</sub> and greenhouse gas emissions, which results in pollution <sup>[1]</sup>. Additionally, the number of people living in cities is continually growing; by 2050, 68% of the world's population is predicted to reside in cities <sup>[2]</sup>. Rising populations increase other major concerns, such as community safety, the efficiency of mobility, and poor quality of life, especially in districts and neighborhoods.

The neighborhood or district is an important scale of development to consider since it is the core of cities. If neighborhoods suffer then cities subsequently suffer, moreover, neighborhoods need attention in order to develop livable and sustainable environments. Moreover, smart neighborhoods improve the social networking and capital of the populace <sup>[3]</sup>. Smart cities can be developed at different geographical scales, starting from the neighborhood, and should lead to the enhancement of quality of life and neighborhood livability <sup>[4]</sup>. The integration and growth of smart cities and smart neighborhoods can therefore help to alleviate the effects of urbanization and the environmental risks that most cities, especially in developing countries, are currently facing. This requires the development of new, functional, and user-friendly services and technologies, especially in the fields of energy, transportation, and information and communication technology (ICT). These solutions also need a combination of approaches in terms of advanced technology solutions, research, innovation, and deployment <sup>[5]</sup>.

Several urban computing strategies can be deployed to support the systematic development of smart neighborhoods. Urban computing involves the use of smart technologies and the internet of things (IoT) as tools to reach sustainability and progressively foster resilient neighborhoods. Furthermore, it is essential to know the neighborhoods and citizens' needs to implement the right strategies and methods of smart technology to promote sustainability. Additionally, it is not only about smart technologies but also about the collection of relevant data that can guide us to solutions <sup>[6]</sup>. Moreover, the considerations should include how to manage the data and connect technology with neighborhood challenges to resolve them. Urban computing is generally understood to be a technique for acquiring, integrating, and analyzing large-scale heterogeneous data created by a range of resources inside urban environments, such as sensors, gadgets, cars, structures, and humans <sup>[7]</sup>. It is relevant to urban informatics, which involves the application of information and communication technologies in managing and understanding urban areas <sup>[8]</sup>.

In the context of Saudi Arabia, it has been deduced from various literature reviews that there is a lack of a smart and sustainable framework for Saudi neighborhoods, especially in the use of smart technologies to support sustainable development. Recent studies have examined social sustainability in Saudi neighborhoods <sup>[9]</sup>, greenspace usability <sup>[10]</sup>, heritage management <sup>[11]</sup>, the transformation of housing typology <sup>[12]</sup>, and life-cycle-based strategic framework for smart sustainable cities at the city scale <sup>[13]</sup>. Thus, the focus is to discuss the development of a smart and sustainable neighborhood framework by applying the concept of urban computing and various smart and sustainable standards. The development of the proposed framework goes through a process; firstly, starting by exploring multiple strategies and other

frameworks from various literature reviews on the concept of urban computing. Then secondly, examining and analyzing sustainable cities or neighborhood standards in addition to smart standards. Consequently, the proposed framework is tested for its success in maintaining an economic, environmental, and social neighborhood by applying it to the Alkhaledia district in Jizan. The framework has the goal of creating an inclusive neighborhood, with a focus on having social connectivity and environmental protection. This goal, which is relevant to the current need of Saudi districts, applies to other communities. More importantly, the Saudi Arabia Vision 2030 features focus areas of “vibrant society”, “thriving economy”, and “ambitious nation”, which establish the need for more sustainability-oriented neighborhoods that facilitate smart technologies to support sustainability and its measures.

## **2. Development of Urban Computing Framework for Smart and Sustainable Neighborhoods**

### **2.1. Smart Neighborhood**

A new development paradigm combines urban sustainability with smartness, emphasizing the significance of taking both issues into account simultaneously <sup>[14]</sup>. It was developed in response to the criticism of smart urban strategies that conflict with sustainability, as well as an effort to address the needs of today's highly digitalized cities in a more comprehensive way than the conventional concept of sustainability allows, and that could be implemented on a neighborhood level <sup>[15]</sup>. The sustainable development goals (SDGs) are relevant to this content because smart city solutions are expected to play a key role in supporting cities and communities in reaching these goals by aiding stakeholders in controlling and measuring progress toward the SDGs using widely accepted indicators. Recently, attention has focused on how smart solutions can help elevate the quality of life and enhance sustainability of neighborhoods <sup>[4]</sup>.

### **2.2. Sustainable Neighborhoods**

In Saudi Arabia, specifically, achieving sustainability is a challenging task. There are many impediments to overcome to attain sustainability goals <sup>[16]</sup>. Despite these challenges, the Saudi Arabian government aspires to make the country one of the most sustainable in the region and to set it as an inspiring example for other nations. Existing conditions must be reviewed at several scales, including regions, cities, districts, neighborhoods, and buildings, to attain sustainability. The neighborhood is the city's smallest planning unit, which contains a variety of elements, such as houses, streets, people, open spaces, and so on <sup>[17]</sup>. Therefore, achieving a smart and sustainable neighborhood is a good start to attain sustainability for life quality and well-being.

To address current urbanization issues, such as population increase, urban sprawl, poverty, inequality, pollution, overcrowding, urban biodiversity, urban mobility, and energy, the UN-Habitat (the United Nations Human Settlements Program for human settlements and sustainable urban development) assists nations in developing urban planning concepts and systems. The proposed plan is based on five principles that encourage compactness, integration, and connectedness, which are three essential attributes of sustainable communities <sup>[18]</sup>. The five guiding principles are population concentration, mixed-use development, social variety, adequate street space, and limited land-use specialization. These principles are the prime focus of assessing the sustainability of the Alkhaledia district and providing possible solutions, if any, for the missing factors.

### **2.3. Smart and Sustainable Indicators for Neighborhoods and Communities**

The International Telecommunication Union's (ITU) definition of “smart sustainable cities” is divided into two parts: the first describes a city's smart characteristics, while the second describes urban sustainability <sup>[19]</sup>. The use of information and communication technologies (ICTs) to improve quality of life, the efficiency of urban operations, and competitiveness, for instance, are examples of innovations that are associated with smart city characteristics. These innovations aim to improve the quality of life, efficiency of urban activities and services, and citizen involvement. Moreover, a city's sustainable characteristics are those that guarantee that it fulfills the economic, social, environmental, and cultural needs of both present and future generations <sup>[15]</sup>. Therefore, the proposed framework integrates smart indicators for the development of smart neighborhoods, combined with some sustainable indicators for the environmental, economic, and cultural aspects of a sustainable neighborhood with the focus on urban computing and its strategies as the inspiration for a clearer and more strategic framework for smart and sustainable neighborhoods or cities.

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